Week 5 Challenge Homework

Electric Field

Submission Details | Submit a digital copy (PDF, jpg, etc.) to Canvas. Include solutions to the metacognitive exercise and each question. Please use the interface to associate each page of your submission with the assignment. It makes grading much easier. Please clearly indicate which question is being solved. If data is needed to complete a problem, be sure to cite the source you've acquired your data from. Typed work will not receive credit. See the course website for further details.

Group Submissions | You may submit a group collaboration to Canvas. Add each group member to the submission. Each group member should contribute to the work. Clearly indicate which part of the submission is written by each member (color or labels are preferable).

Sensemaking | You will be asked to apply sensemaking in some problems. More information about sense-making can be found on the BoxSand Sensemaking page, which is linked on the Canvas homepage.

Metacognitive Exercise

Each week will feature a metacognitive exercise, followed by one or two challenge problems to solve. The metacognitive exercise will usually ask you to reflect on your solution to the previous week's challenge problems.

Review your solution to the Week 4 Challenge Homework. If you do not have a copy of it anymore, you can find it on Canvas or Gradescope, under the Week 4 Challenge Homework assignment. Also, review the solution which has been posted to the BoxSand solutions archive (click here for a link). Solutions are posted a few days after the assignment is due.

(a) The new sensemaking techniques that are introduced in PH203 are "special cases" and "self-consistency". Special cases sensemaking can be especially challenging (and also powerful!). Describe it in a few of your own words.

(b) Look back at the sensemaking you completed in the Week 4 Challenge Homework and the provided solution on the solutions archive. In a sentence or two, what are your feelings, comfort with, and/or questions about special cases sensemaking?

Question 1

A proton is fired directly into a uniform electric field. The field is able to momentarily reduce the charge's momentum to zero.

(a) What must be the orientation of the electric field relative to the initial momentum of the proton?
(b) What type of charge configuration would generate a uniform electric field?
(c) If the proton is initially traveling at **5% the speed of light**, what field strength will stop the charge within **1.00 cm** of entering the field region?
(d) How much work does the electric field do in stopping the proton? Answer this by finding the change in kinetic energy of the proton. Remember that work and kinetic energy are related by $W = \Delta KE$.
(e) Use the self-consistency sensemaking technique to test your answers to parts (c) and (d) by answering the following prompts.
  (i) Using your answer to part (c) and the distance the proton travels into the field, find the work done on the proton using the relationship $W = \vec{F} \cdot \Delta\vec{r}$
  (ii) Compare your answers to parts (i) and (d) and show that they are in agreement.

Question 2

Three **+2 μC** point charges are fixed in space in the following locations: the first at **<1, 0, 0> cm**, second at **<0, 2, 0> cm**, and a third at **<-4, 0, 0> cm**.

(a) Find the net electric field vector at position **<-1, 1, 0> cm**. (hint: draw a diagram!)
(b) At this location, what is the force vector on a **-3 μC** test charge?
(c) Use the sign sense-making technique to check that your answers to parts (b) and (a) are consistent by answering the following prompts.
  (i) Make a prediction for the relationship between the direction of an electric field vector and the direction of the force on a negatively charged particle placed in that electric field. Explain what this means for the signs of each component (X, Y, and Z) of the force and electric field.
  (ii) Compare your prediction with the answers you found in parts (a) and (b) and show that they are consistent.